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(71) Applicant *(for all designated States except US)*: **KONINKLIJKE PHILIPS ELECTRONICS N.V.** [NL/NL]; Groenewoudseweg 1, NL-5621 BA Eindhoven (NL).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: **HECTOR, Jason, R.** [GB/GB]; c/o Prof. Holstlaan 6, NL-5656 AA Eindhoven (NL). **YOUNG, Nigel, D.** [GB/GB]; c/o Prof. Holstlaan 6, NL-5656 AA Eindhoven (NL). **FISH, David, A.** [GB/GB]; c/o Prof. Holstlaan 6, NL-5656 AA Eindhoven (NL). **CHILDS, Mark, J.** [GB/GB]; c/o Prof. Holstlaan 6, NL-5656 AA Eindhoven (NL).

(74) Agent: **WHITE, Andrew, G.**; Internationaal Octrooibureau B.V., Prof. Holstlaan 6, NL-5656 AA Eindhoven (NL).

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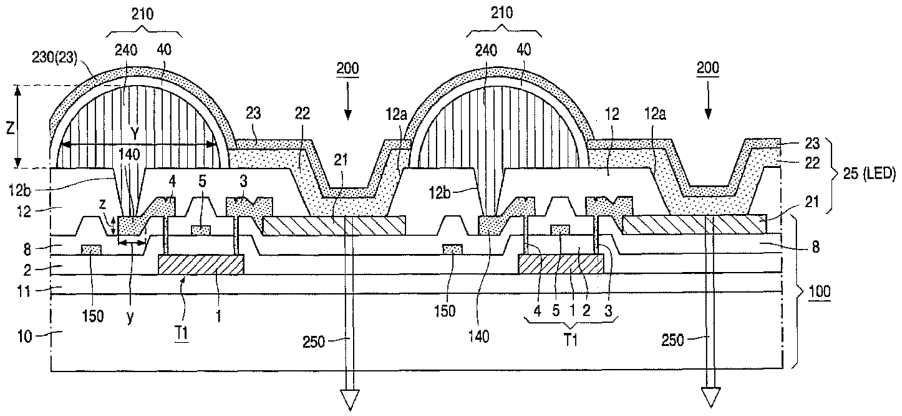
(54) Title: ACTIVE MATRIX ELECTROLUMINESCENT DISPLAY DEVICES, AND THEIR MANUFACTURE



(57) Abstract: Physical barriers (210) are present between neighbouring pixels (200) on a circuit substrate (100) of an active-matrix electroluminescent display device, particularly with LEDs (25) of organic semiconductor materials. The invention forms these barriers (210) with metal or other electrically-conductive material (240), that is insulated (40) from the LEDs but connected to the circuitry within the substrate (100). This conductive barrier material (240) backs-up or replaces at least a part of the drive supply line (140,240) to which the LEDs are connected by a drive element T1. This transfers the problem of line resistance and associated voltage drop from within the circuit substrate (100), where it is severely constrained, to the much freer environment of the pixel barriers (210) on the substrate (100) where the conductive barrier material (240) can provide much lower resistance. Very large displays can be made with low voltage drops along this composite drive supply line (140,240). Furthermore, the structure can be optimised to form a smoothing capacitor (Cs) between this drive supply line (140,240) with its conductive barrier material (240) and the further supply line (230) of the LED upper electrodes (23) extending on an insulating coating (40) over the top of the conductive barrier material (240).

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DESCRIPTION

ACTIVE MATRIX ELECTROLUMINESCENT DISPLAY DEVICES, AND THEIR MANUFACTURE.

This invention relates to active-matrix electroluminescent display devices, particularly but not exclusively using light-emitting diodes of semiconducting conjugated polymer or other organic semiconductor materials. The invention also relates to methods of manufacturing such devices.

Such active-matrix electroluminescent display devices are known, comprising an array of pixels that is present on a circuit substrate, wherein each pixel comprises a current-driven electroluminescent element, typically of organic semiconductor material.

In many such arrays, physical barriers of insulating material are present between neighbouring pixels in at least one direction of the array. Examples of such barriers are given in published United Kingdom patent application GB-A-2 347 017, published PCT patent application WO-A1-99/43031, published European patent applications EP-A-0 895 219, EP-A-1 096 568, and EP-A-1 102 317, the whole contents of which are hereby incorporated herein as reference material.

Such barriers are sometimes termed "walls", "partitions", "banks", "ribs", "separators", or "dams", for example. As can be seen from the cited references, they may serve several functions. They may be used in manufacture to define electroluminescent layers and/or electrode layers of the individual pixels and/or of columns of pixels. Thus, for example, the barriers prevent pixel overflow of conjugate polymer materials that may be ink-jet printed for red, green and blue pixels of a colour display or spin-coated for a monochrome display. The barriers in the manufactured device can provide a well-defined optical separation of pixels. They may also carry or comprise conductive material (such as upper electrode material of the electroluminescent element), as auxiliary wiring for reducing the resistance of

(and hence the voltage drops across) the common upper electrode of the electroluminescent elements.

Each electroluminescent element of an active-matrix display device is connected in series with a drive element (typically a thin-film transistor, hereafter termed "TFT") between two voltage supply lines of the array. These two supply lines are typically a power supply line and a ground line (also termed "return line"). Light emission from the electroluminescent element, typically a LED, is controlled by the current flow therethrough, as altered by its respective drive element TFT. The supply line to which the electroluminescent elements are connected by their series drive elements may be termed the "drive supply line" or "drive line" or "current drive line" of the pixels. Voltage drops along these two supply lines can result in incorrect drive currents for individual pixels. This can lead to a decrease in emission intensity (i.e. fading of the image) from pixels in the centre of the display. Indeed, with large-area displays, the effect may be so bad that no emission occurs at the centre, so limiting the acceptable display size.

Several measures have been proposed in order to reduce such voltage drops and/or their effects for a row of pixels. Thus, it is known from published United States patent application US-A1-2001/0007413 (Philips ref: PHGB000001) to reduce voltage drops along the line by tapering the width of the line. Published PCT patent applications WO-A1-01/01383 and WO-A1-01/01384 (Philips refs: PHB34350 & PHB34351) adopt a different approach in which error values are generated to correct the drive signals for each pixel. The whole contents of US-A1-2001/0007413, WO-A1-01/01383 and WO-A1-01/01384 are also hereby incorporated herein as reference material.

It is an aim of the present invention to reduce such voltage drops along the drive supply line, and to do so in a manner that does not significantly complicate the device structure, its layout and its electronics.

According to one aspect of the present invention, there is provided an active-matrix electroluminescent display device with the features of Claim 1.

In accordance with the invention, the physical barriers between pixels are partly and/or predominantly of electrically-conductive material (typically metal) that is insulated from the electroluminescent elements and that provides at least a part of the drive supply line. This conductive barrier material may form a conductive core of the barrier. It is connected into the circuit substrate, to electrode connections for the respective drive elements, via contact windows (hereinafter termed "vias") between the pixel barriers and the drive elements in the substrate. Thus, the problem of line resistance and associated voltage drop is transferred from within the circuit substrate (where it is severely constrained) to the much freer environment of the pixel barriers on the substrate (where the conductive barrier material can provide much lower resistance).

By this means, the electrical resistance along the drive supply line (and consequential voltage drops) can be significantly reduced, as compared with a conductor layer within the circuit substrate, for example a thin-film electrode line of the drive element. Thus, along this drive line, the conductive barrier material has a cross-sectional area that is typically larger (for example, at least twice as large as, or even at least an order of magnitude larger) than that of a thin conductor layer in the circuit substrate. As such, the resistance (even of long lines) can be low, and very large electroluminescent displays can be constructed in accordance with the invention. Even with smaller displays, the image quality can be improved by use of the conductive barrier material in accordance with the present invention.

By providing one via per pixel, continuous barrier lines of conductive material on the circuit substrate can be used to replace the drive lines that were previously incorporated within the circuit substrate. This permits an increase in pixel aperture. The conductive barrier line itself may simply overlap with a column or row conductor line of the array. Alternatively, lines (or individual lengths) of the conductive barrier material may be used to back-up corresponding lengths of a drive line of the circuit substrate. This alternative provides greater choice in the number and location of the vias.

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